DOCUMENT RESUME

ED 244 557 HE 017 260

AUTHOR McCredie, John W.
TITLE Gateways among Academic Computer Networks.
PUB DATE Dec 83
NOTE 13p.; In: Information Resources and the Individual. Proceedings of the CAUSE National Conference (San Francisco, CA, December 11-14, 1983). Boulder, CO, CAUSE, 1984, p. 187-198. For the complete proceedings, see HE 017 245.
PUB TYPE Viewpoints (120) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Computer Oriented Programs; *Coordination; *Databases; Higher Education; *Information Networks; *Information Systems; *Intercollegiate Cooperation

ABSTRACT

National intercampus computer networks are discussed, along with six illustrative networks. Attention is focused on computer networks with significant academic usage through which special software is available to manage resources in the network. It is noted that computer networks have widespread use among academics for communication in the form of short mail type messages, reports, drafts of papers, data, programs, and requests for comments and assistance. Brief descriptions are provided of the following networks: ARPAnet, BITNET, CSNET, EDUNET, MAILNET, and USENET. It is suggested that gateways among networks offer the only reasonable technical and organizational approach to the problems inherent in the proliferation of academic networks. Examples of internetwork gateways are cited, including the close link between ARPAnet and CSNET. The following organizational problems with gateways among networks are noted: internetwork addressing standards, and internetwork pricing and charging incompatibilities. (SW)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED244557

GATEWAYS AMONG ACADEMIC COMPUTER NETWORKS

by

Dr. John W. McCredie
President of EDUCOM
Box 364
Princeton, New Jersey 08540
Telephone 609-734-1915

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

CAUSE

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

U.S. DEPARTMENT OF EDUCATION
NATIONAL INSTITUTE OF EDUCATION
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

☐ This document has been reproduced as received from the person or organization originating it.

☑ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official NIE position or policy.

ABSTRACT

Academic computer networks in the United States are growing rapidly to support the expanding needs for computer-based communication of scholars and administrators in higher education. Both local area networks for intra-campus facilities, and national inter-campus networks are of great interest. This growth will accelerate in the foreseeable future as computers of all sizes spread rapidly through colleges and universities.

Individuals on campuses throughout the country are evaluating dozens of local area networking options to discover ways of satisfying voice, data, and video telecommunications requirements. Several universities have connections to more than five national networks. Most information technology managers are concerned about which network they should join, and several are building connections among different networks that serve their campuses.

Since there are no political forces to limit them in the United States, academic networks will continue to grow in size and to proliferate in variety. This growth will be compounded by the constantly decreasing cost of computer hardware. This proliferation has obvious associated costs and disadvantages. However, the newness of this field and the dynamic growth of new ideas are such that it is premature to try to restrict the growth with artificial means. Connections among networks offer the only reasonable short-term technical and organizational approach to the problems inherent in this proliferation. Commercial standardization, in the long run, will lead to computer networks that are interconnected in ways similar to present telephone networks.

This paper will focus on national, intercampus networks. Brief descriptions of several of these networks (ARAnet, BITNET, CSNET, EDUNET, MAILNET, RLIN, USENET, etc.) will illustrate the wide range of academic applications currently available, and the need for network interconnections.

HE 017 360

Paper presented at the
CAUSE National Conference
(San Francisco, CA, Dec. 11-14, 1983)

THE COMPUTER NETWORKING ENVIRONMENT IN AMERICAN HIGHER EDUCATION

Definition

Computer networking, like many other technical concepts, is difficult to define well because it means many different things to many people. For the purposes of this paper I shall concentrate on networks having the following features:

- o a system of interconnected, autonomous computers, terminals and communications facilities
- o at least national in scope with significant academic usage
- o availability of special software to manage resources in the network, and
- o lists of host computers and users with their associated network addresses

Several important types of academic networks are beyond the scope of this paper (e.g. local area networks connecting computer systems on a campus, and regional networks serving a specific geographical area, such as a state). Many universities are in the process of wiring their campuses with different local area networks. For example, Carnegie-Mellon University is involved with a multi-million dollar joint study with the IBM Corporation to develop advanced scholarly workstations that are connected to each other in a high capacity local communications network. Dartmouth College is designing its own network to connect thousands of workstations, and Brown University has wired its campus with a broad-band network that carries both video signals and computer communications. The University of Chicago has installed a local telephone system that integrates voice and data on the same network, and dozens of other universities are experimenting with fiber optics and base- and broad-band technologies. Because of time limitations, this presentation will concentrate on national computer-based networks -- not on the equally exciting field of local area networks.

The term "network" is often used to refer to both a collection of computers and communication hardware, (physical network) and the groups of individuals connected by telecommunication links (logical network). A particular computer may be part of several different physical networks at the same time. More often, an individual will belong to more than one networking group, possibly on different physical networks. For example, a colleague of the author has six different network addresses, in addition to a postal address, on his business card.

Most higher education networks are based on the diverse needs of many individuals rather than on one underlying large system required to support the "business" of the institution. Such academic networks stand in sharp contrast to the high transaction rates and tight control structures of many commercial networks designed to support an organization's needs for reservation, order entry, and/or electronic fund transfer facilities.

Typical Academic Applications

In order to understand how computer networking is evolving in the academic community, it is useful to examine both the broad categories of applications most common today and those that are growing quickly.

Many important applications belong to the broad class of resource sharing uses. To replicate unique hardware, software, and data resources on every campus is prohibitively expensive. Consider, for example, the costs of operating the largest available supercomputers on many different campuses to satisfy the computational requirements of relatively few researchers. It is more economical to satisfy most common computing needs locally, and to access remote resources for important, but not heavily-used applications. The same argument can be made for sharing unique software and data resources.

Several successful networking applications in higher education have been justified using resource sharing arguments, but the actual number of such cases is fewer than was predicted several years ago. For example, a 1966 summer study of information networks conducted by EDUCOM reported:

> "Thus, a network could facilitate making the resources of one institution available to others. Universities could share library materials, data banks, computing facilities, ..."[1]

The rapidly-declining costs of hardware and the almost universal desire for local, even individual, control of information processing facilities, are two of the strongest pressures for localized computing capabilities. The relative lack of importance of academic resource sharing contrasts with many networks in the private sector where resource sharing is of paramount importance -- for example the strong motivation to share airline reservation information among many companies and passengers.

If resource sharing, although vital to some applications, is not the primary driving force in much of academic networking, what is? Communication among people is the obvious answer. Most academics must communicate with others to accomplish their goals. Since they are often separated from peers by large distances, and since the nature of their work is often collaborative and asynchronous, faculty, students, and administrators who have tried computer communication networks have, by and large, found them to be useful. Traditional communication channels (annual meetings, mail, telephone, etc.) do not have the needed capacity, or more importantly, the appropriate response time.

Many items are routinely sent electronically by people with access to computer networks -- short mail-type messages, reports, drafts of papers, data, programs, preliminary ideas, requests for comments and help, etc. Computer-based communication in networks has always been valuable, but often its importance was not freely admitted because it was not the primary reason for a network. Interpersonal communications are growing rapidly in all networks known to the author. Once many independent system components are in place, communication applications among previously disjoint elements are often important enough to justify networking. The widespread use of computer networks for communicating is causing new forms of computer-based communication services to be developed. Electronic bulletin boards and sophisticated conferencing systems are two examples popular in higher education.

SIX ILLUSTRATIVE NETWORKS

ARPAnet

In the late 1960s, the Advanced Research Project Agency of the U.S. Department of Defense established a basic research effort in computer networks. ARPA (now DARPA) made several grants to corporations and to academic computer science departments to help develop the field of computer networking. This research led to the implementation of a small prototype network in 1969 that has grown to approximately 100 nodes (and almost 200 computers) distributed throughout the U.S. and several other countries. These nodes are connected mostly by leased telephone lines, and in a few cases, by leased satellite channels.

Many of the important concepts, such as packet switching, commonly used in several operational networks, were developed by these research projects. The results of these developments had immediate positive impacts on the computer science community, and ARPAnet became very popular within colleges and universities. In a technical sense, ARPAnet is the real father of modern academic networking in the United States.

The host computers were those involved in research projects supported by DARPA. Thus the early ARPAnet served two primary purposes -- it connected an important group of computer scientists who were working on problems of interest to the entire group, and it served as a pioneering research vehicle for development work on networking. A. Newell and R. Sproull report that:

> "(ARPAnet) hosts still represent the full spectrum of university and industrial research groups in computer science, but also now include numerous military organizations with diverse operational missions. The network is essentially saturated..... The traffic consists largely of mail messages and files, the latter containing programs, data, or text. There is substantial remote access, and several organizations use the net to do all of their computing remotely. The use of the ARPAnet has become integral to the operation of many of the organizations connected to it."[2]

A problem of ARPAnet in higher education has been its strict policy of

limited access. Since it served both research and operational Defense Department roles, ARPAnet has not been able to expand to satisfy the needs of academic computer scientists who are not part of the DARPA community. In 1983, APRAnet separated the research and development activities from the operational activites and created two distinct networks. ARPAnet has obviously been unable to expand to accomodate faculty in other disciplines.

CSNET

Because of ARPAnet restrictions on membership, the University of Wisconsin at Madison, on behalf of 15 other participating institutions submitted a networking proposal to the National Science Foundation. In January, 1981, NSF approved funding of approximately $5 million for a computer science research network (CSNET). CSNET is a computer science community effort to provide open network services throughout the United States to computer scientists. There is cooperation between the Department of Defense and NSF to allow message communication between CSNET users and ARPANET sites. Presently 19 CSNET members also participate in ARPANET.

At the end of 1982 there were about 70 participating sites in the first phases of CSNET. An NSF program solicitation for an organization to manage, operate, and develop CSNET, describes the network as follows:

> "The Computer Science Research Network (CSNET) is a project of the National Science Foundation that is intended to provide network services and access for all qualified computer science researchers. It is a logical network utilizing the services of several physical networks.... Over the long term, CSNET must meet the network needs of the computer science research community sufficiently well to generate its own financial support....."[3]

CSNET is growing rapidly among computer science departments. There are three major kinds of services the network will eventually offer:

- network mail including an addressing (directory) facility
- file transfer from one CSNET host to another
- remote login, the ability to use a remote host as if it were local.

EDUNET and MAILNET

In 1979, EDUCOM, a non-profit consortium of a more than 450 participating colleges and universities, announced the operational phase of EDUNET, a computer network that was founded to meet the general networking needs of higher education. The design of EDUNET came from the work of The Planning Council on Computing in Education and Research which was composed of about 20 universities. The Council met for several years to study the kinds of networking arrangements that could best lead to a self-sustaining organization capable of providing viable academic network services. The Planning Council grew from ideas developed at three seminars conducted in late 1972 and early 1973 by EDUCOM with the support of the National Science Foundation.

EDUNET's primary focus has been to make it easy for people located throughout the world to interact directly with sophisticated computer resources supported by 19 host institutions.

EDUNET has evolved into an international computing network for higher education, research organizations, and not-for-profit companies. To promote the sharing of computerized resources, EDUNET provides access to specialized programs, services, and databases of 18 leading university computer centers in the United States. In addition, the University of Stockholm, Sweden recently became the 19th, and the first international, supplier.

Typical services include electronic mail and conferencing, access to unique computer hardware (e.g., the CRAY-1 supercomputer at the University of Minnesota), database management, modeling, and hundreds of programs in topical subject areas. EDUNET services are used by administrators, faculty, and students in more than 150 participating institutions. Services can be accessed through terminals, microcomputers, and word processors with communications capabilities. Local access is available in 250 U.S. cities and 30 foreign countries through public data communication companies such as Telenet and TYMNET.

Electronic mail and computer-based conferencing are the fastest growing services provided by EDUNET suppliers. A new EDUCOM activity is MAILNET, a project to transfer the electronic messaging facilities developed by the CSNET project beyond the computer science research community to all of higher education. MAILNET will link together local campus-based electronic mail systems to support transmission of messages and documents between persons on different campuses -- all of whom use their own local electronic mail systems. Virtually any campus electronic mail system may connect to Mailnet regardless of the type of computer or operating system used.

At the present time, 14 universities are connected directly to MAILNET, including sites in the United Kingdom and Sweden. Ten more universities are in the process of implementing direct connections, and by this spring, well over 100 colleges and universities will be addressable by network gateways.

BITNET

BITNET is a rapidly expanding network of more than 100 computers located at approximately 40 universities. The first link was established between The City University of New York and Yale University in May 1981. The network is based on a software product developed and used internally by IBM to support a multi-national internal corporate network (VNET) of more than 1,000 nodes. The software provides store-and-forward message capabilities. The only special networking hardware required is a modem and a leased telephone line to the nearest BITNET host.

In the past, BITNET software was available only on IBM computers, but recently the communication protocols were developed at Penn State University to enable several kinds of computers made by Digital Equipment Corporation to be part of BITNET. Ira Fuchs, one of the organizers of BITNET, describes it in the following way:

> "The primary purpose of BITNET is to facilitate communications among universities by lowering the threshold of effort normally associated with other means of exchange. BITNET was designed using simple,

> inexpensive software and cost-effective telecommunications facilities. Thus an institution can connect to BITNET easily, with negligible programming effort and cost, providing speedy and simple access for faculty and staff. BITNET users share information via electronic mail, specifically in the form of interactive messages, text files, and computer programs."[4]

One of the interesting aspects of BITNET is that there is no central management of the network, or paid staff. Each site pays for the cost of the telephone link to the next BITNET site. The administrative, technical, and operational costs of running the network are shared by each participating organization. BITNET will soon extend into Canada, and a direct link to Europe is currently being implemented.

USENET

USENET, an informal network of more than 500 computer systems running the UNIX* Operating System, is similar in many ways to BITNET. Several years ago students extended a communications package that is part of the UNIX system to include a news facility. This facility is really an electronic bulletin board to which sites may subscribe for various services ranging from news about data communications and microcomputers to wine tasting and jokes. An extensive electronic mail facility is a part of USENET. Systems can enter and leave USENET very easily since there is really no central administrative structure. One drawback of the informality of this network is that users must know, and specify, valid routings through the network to reach users at other sites.

---

* UNIX is a trademark of Bell Laboratories.

Library Networks

There are several important library networks supporting activities in higher education that are very different from those described in the preceding paragraphs. The largest of these networks is OCLC which was established in 1971 to provide cataloging support to libraries in Ohio.

The organization has now grown into an international network serving all types of libraries. Several regional networks collaborated with OCLC to spread its services throughout the United States and into Canada and the United Kingdom. Two other major bibliographic systems have emerged in the United States -- WLN, the Washington Library network, and RLIN, the Research Libraries Information Network.

It is beyond the scope of this paper to explore these networks in any depth, but they must be discussed briefly because of their uniqueness and importance. These networks have emerged not along discipline lines like CSNET or COGNET, nor because a technology was available like BITNET or USENET, but because of functional specialization and the need for resource sharing on a grand scale. Large bibliographic information retrieval systems face many of the problems of other networks, and in addition, they have specialized technical and legal concerns. For example, there are very complex legal, political, and economic implications concerning the sharing and exchange of bibliographic data among operating libraries. Who owns the data and how may it be distributed? Many of the organizational and technical developments in this field are such that precedents and ground rules do not yet exist.

Several companies provide abstracting and indexing services that are widely used in higher education in addition to other market areas. These services are usually provided through campus libraries with trained staff members serving as the interface to the information retrieval networks.

FUTURE TRENDS IN ACADEMIC NETWORKING

Since there are no political forces in the United States to limit the number of different academic networks, the author believes they will continue to grow in size and to proliferate in variety. This growth will be compounded by the constantly decreasing cost of computer hardware. This proliferation has obvious associated costs and disadvantages. However, the newness of this field and the dynamic growth of new ideas are such that it is premature to try to restrict the growth with artificial means. Gateways among networks offer the only reasonable technical and organizational

approach to the problems inherent in this proliferation.

Several inter-network academic gateways already exist, and others are under development. For example, ARPAnet and CSNET have been closely linked from the beginning. Recently computer scientists at the University of Wisconsin designed and implemented a gateway between CSNET and BITNET that is being tested. Developers at the City University of New York and the IBM Cambridge Science Center designed and implemented a gateway between BITNET and VNET, the internal IBM multi-national network. This gateway had to pass rigid security tests imposed by IBM before it became operational. A gateway between a network of several universities using DECnet and BITNET has been operating successfully for more than a year, and a gateway between MAILNET and BITNET is currently being tested at Cornell University.

Most of the technical problems with the design of successful gateways among networks have been solved, but large organizational problems remain. For example, internetwork addressing standards have not yet been widely adopted, and many of the current solutions are too informal and ad hoc. Another organizational problem is internetwork pricing and charging incompatibilities. Most networks charge users for each message, but some (e.g. BITNET) have no variable charges for traffic. Clearly these different pricing philosophies cause problems when internetwork traffic begins to get grow.

Computer networks will eventually interconnect as smoothly as current telephone networks. Corporations will offer increasingly more valuable services, and discipline-based networks will probably not manage and operate their own long distance communications links. If one technology or service emerges that is clearly superior to, and more economical than, all others, it will be widely adopted for new applicaitons. However, successful older networks will continue to exist for a long time.

Network information and management centers are emerging to formulate solutions to these problems. For example, BBN Inc., a Cambridge Massachussetts firm, operates a Network Information Center for CSNET. EDUCOM and City University of New York are working together to develop a

joint Network Support Center for BITNET. EDUCOM will supply user service facilities to the rapidly expanding academic networking community, and City University will develop needed software and operate a Network Support Machine that will provide important facilities such as network address information for users and directories of software and hardware resources. This proposed Network Support Center will also coordinate the design and operation of gateways among BITNET and several other academic networks including a BITNET link to Europe which will become operational this spring.

Computer-based networking activity is beginning to expand between the United States and Europe. Several interesting networks exist in the European higher education community, and efforts are underway to expand gateways to American networks. It seems obvious that academic networking connections between the U.S. and other countries will grow in importance as the technology evolves. Of course, the most important incentive to this growth will be the emergence of groups of academics in different countries who want to use computer networks to communicate. The technology is ready and waiting to support such international cooperation.

REFERENCES

1. Brown, Miller, and Keenan, EDUNET: Report of the Summer Study on Information Networks, John Wiley & Sons, 1967, pg. 323

2. A. Newell, and R. Sproull, "Computer Networks: Prospects for Scientists," Science, Vol. 215, Feb. 12, 1982, pg 847

3. National Science Foundation program solicitation, Mathematical and Computer Sciences Division, November 5, 1982

4. Ira Fuchs, "BITNET - Because It's Time," Perspectives on Computing, IBM, Vol. 3, No. 1, March 1983, pg. 17.

ACKNOWLEDGMENT

Many individuals at EDUCOM and in its member colleges and universities contributed ideas to this paper, and I would like to thank them collectively for their assistance. William Timlake, of the IBM Corporation, worked closely with the author on a related paper and deserves special thanks for his many contributions.